A CROSS SECTIONAL STUDY OF FIELD INDEPENDENCE AND UNITED STATES MILITARY AIR TRAFFIC CONTROL SPECIALISTS

by

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14. ABSTRACT
This study examined whether samples of active duty military Air Trafic Control Speciliasts (ATCSs) from the United States Air Force (USAF) and the United States Navy (USN) contained a greater number of participants who possessed the underlying ability or trait, of field independence than those participants who were in the control group of non-ATCS military personnel. The Embedded Figures Test (EFT) is one test that measures field dependence. Three groups of active duty military personnel were administered the EFT. The first sample consisted of 19 active duty USAF ATCSs. The second consisted of 19 active duty USN ATCSs, and the third group consisted of 19 active duty military non-ATCS personnel. The hypothesis was that participants who were active duty military ATCS' (with ATC experience), would be more field independent than those in other specialties. Results indicated that a significant statistical difference existed between the EFT scores of the USAF ATCSs and the control group.

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Field dependence/independence is one dimension of human cognitive functioning. Field dependent people have difficulty disembedding one particular item, picture, or symbol from the whole view. Field independent people are thought to be better at distinguishing relevant from irrelevant cues in their environment. This study examined whether samples of active duty military Air Traffic Control Specialists (ATCSs) from the United States Air Force (USAF) and the United States Navy (USN) contained a greater number of participants who possessed the underlying ability or trait of field independence than those participants who were in the control group of non-controller military personnel. If true, field independence may be a possible selection criterion for ATCS candidates.

The Embedded Figures Test (EFT) is one test that measures field dependence. The EFT was developed by Herman A. Witkin. In this study three groups of active duty military personnel located at two local military installations completed the EFT. The first sample consisted of 19 active duty United States Air Force ATCSs. The

second consisted of 19 active duty United States Navy ATCSs, and the third group consisted of 19 active duty military non-ATCS personnel. The hypothesis was that participants who were active duty military ATCS' (with ATC experience), would be more field independent than those in other specialties. Results indicated that a significant statistical difference existed between the EFT scores of the USAF ATCSs and the control group. There was not a significant statistical difference in the EFT scores between the USN ATCSs and the control group. However, these two groups were more similar in the non-controlled variables of age, gender composition, and education, which may account for that finding.

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CHAPTER 1

INTRODUCTION

The pre-screening and selection of air traffic control personnel has been a subject of continuing study for the past six decades (Broach & Manning, 1997; Brokaw, 1984; DellaRocco, 1998; Schroeder, Dollar & Nye, 1990). During this time, researchers developed several tests that aid in the process of the initial screening and selection of for Air Traffic Control Specialist (ATCS) candidates. To some extent these tests have been successful in lessening the time needed and thereby the cost for selection of ATCS candidates.

With the elimination of mandatory military service in the United States (i.e., "the draft"), the US military is now an all-volunteer force, and volunteers must be recruited. In the past, when the draft was enforced, the military had a continuous influx of incoming personnel. Today, the military invests millions of dollars annually to both recruit and maintain personnel. Unfortunately, this heavy monetary expenditure does not always produce the expected results. The attrition rate for ATCS candidates in training for the United States Armed Forces, as well as the Federal Aviation Administration (FAA), remains high. In addition, the United States Air Force, which is the major military user of ATCS's, has just recently "completed the largest draw down in its 53-year history and has the lowest number of forces since the early 1940's" (Callender, 2000). We see two resultant problems. First, the

recruitment and training have to be almost continuous, as the military must ensure that enough ATCSs finish training to meet air traffic control needs. The second problem is that, due to the insufficient personnel coming through the ATCS pipeline, the workload of the current ATCS workforce is increased. These problems can result in both morale and safety issues for both the military and the FAA. This study examined the use of testing ATCS candidates underlying traits or abilities using the Embedded Figures Test (EFT). Such a test or tests may be able to select ATCS candidates with a higher probability of both completing training and being successful ATCSs. Fleishman and Quaintance (1994) studied underlying abilities and traits. This current research is based on their efforts in part.

Fleishman and Quaintance define an ability as, “an innate enduring attribute” (1984). Messick (1996) defines the relationship between cognition and ability further by stating that, “an ability is concerned with how much, whereas cognitive styles are concerned with the how.” He further states that, “abilities are usually limited to a particular domain of content or function like verbal or memory ability, but cognitive styles are unlimited and reach across the domains of ability, personality, and interpersonal behavior”.

According to Pizzamiglio and Zoccolotti (1986) cognitive style can be defined as the way in which an individual consistently functions in their perceptual and intellectual activities. A cognitive style describes how an individual processes information, not how well they go about processing it. We also find that Witkin (1978) says that the construct of field dependence/independence is a basic ability that is often referred to as a cognitive style. To return to the issue of cognitive style V.

David Hopkin, an expert in the arena of ATC, in his article, “The measurement of the Air Traffic Controller,” stated that there has been quite a bit of research conducted on the subject of cognitive styles in training, and that one of the most promising styles that he would recommend for continued research in the area of selection and training for ATCS is field dependence/independence” (p. 559). This, then, is basically a matter of semantics, as a cognitive style can be considered a basic ability or a direct and causal result of a basic ability.

For the purposes of this study, field dependence is a measure by which all individuals can be classified along a continuum from field dependent to field independent. Field independent people are thought to be more able than field dependent people in that they possess the ability to isolate an essential element from the context in which it is presented. They demonstrate strong cognitive restructuring skills, an ability to segregate and manipulate abstract perceptions, and a propensity to function autonomously (Witkin, 1981). The United States Armed Forces currently use the Armed Services Vocational Aptitude Battery (ASVAB) to screen military candidates and to decide which career fields for which the individual would be best suited. However, at this time, the ASVAB does not include any pattern recognition tests such as the EFT, which has been shown to measure the cognitive style known and field dependence/independence.

Fleischmann (2000), expressed concern that additional research needs to be conducted to determine how certain cognitive processes are performed differently by individuals. He goes further to state that research should be conducted to determine if these individual differences can be related in any way to enduring or innate individual

difference variables. One such individual difference variable is field independence/field dependence, which will be the focus of this study.

PROBLEM STATEMENT

Pre-employment screening, using an underlying abilities approach (Fleischmann & Quaintance, 2000), of ATCS candidates may be able to identify, from the group of applicants, the sub-group that is most likely to complete training. Due to the nature of ATCS training, with its emphasis on job simulations and experiences, it seems logical that the job success rate beyond training will also be impacted. Research has shown that some of the underlying abilities possessed by an ATCS are: problem solving, decision making, information processing, and spatial reasoning (Manning & Broach, 1992). This study focused on whether or not the underlying ability, or trait, of field independence/field dependence is a defining characteristic of ATCS's.

This study investigated the hypothesis that active duty military ATCSs, as a group, tend to be more field independent than a comparable group of military personnel, who are not controllers. If the researcher's hypothesis holds, then field independence may be used as a pre-screening criterion for ATCS candidates by the use of existing (or by developing) valid tests and measures for it. In this study, the dependent variable is field independence/dependence, as measured by the commercial-off-the-shelf (COTS) test called the EFT. The primary independent variable is job classification. Classification variables are age, gender, education, and ATCS experience or lack thereof.

Therefore, the EFT, which is a validated and reliable test, has the potential to be used as a pre-screening tool, or as part of a pre-screening battery, for ATCS candidates. This can lead to lower attrition rates and significant savings.

SCOPE AND LIMITATIONS

Military ATCS generally work in two types of facilities, Tower and Radar Approach Control (RAPCON). Each facility has positions that an ATCS is trained for and assigned to. These are normally called the D (data) side and R (radar) side. According to the Air Traffic Control FAA Order 7110.65; the D side ATCS' are responsible for radar flight data; operating interphones; processing and forwarding flight plan information; compiling statistical data and assisting the facility in meeting situation objectives. The R side ATCS has the responsibility for communicating with aircraft while utilizing radar information as primary means of aircraft separation. To be facility rated in the military, an ATCS must be certified in each position. To be certified in a position an ATCS must demonstrate "the competence, qualifications, and skills required to control traffic at positions included in the type of facility rating issued." (Air Force Flight Standards Agency, 1998). The density of air traffic operations at that facility defines a facilities complexity, where density is determined by a traffic check, which is basically the number of operations per year at that facility. The level of complexity of each position varies from facility to facility. The time allotted to this research limits the number of ATCSs that can be tested. Therefore, this research recruited ATCSs from two military installations, geographically available to the researcher, as test participants.

ASSUMPTIONS

The first assumption is that the sample ATCS's are successful controllers. A second is that their successful performance is related in some manner to their possession of the trait or underlying ability of field dependence/independence.

CHAPTER II

REVIEW OF RELEVANT LITERATURE AND RESEARCH

Cognitive psychology is the study of human memory and mental processes. Modern cognitive psychology can be seen as having an emergence and emphasis in the 1960's, as the study of psychology began to shift from a behaviorist perspective to one of cognitive functioning and processes. The three assumptions of cognitive psychology are: Mental processes exist, humans are active information processors, and that these mental processes can be revealed in time and accuracy measures (Ashcraft, 1994). These time and accuracy measures can and often do shed insight into the way that humans process information.

Humans process information and perform tasks daily. The factors that have an effect on these tasks have been studied for many years. The underlying abilities of the individual performing a specific task have a significant impact on the level of performance of that task. The ability requirements approach developed by Fleishman is a way of describing and classifying human tasks. In this approach, tasks are described, contrasted, and compared to the abilities required of the individual performing a specific task. Abilities, according to Fleishman and Quaintance (2000) are defined as innate enduring attributes. According to the authors, "abilities provide a natural basis for describing and classifying tasks in terms of human performance"(p. 312).

Once a set of tasks are identified, a human performance taxonomy can be developed. A taxonomy can be best described as a system that classifies and describes (human) tasks according to a particular focus, such as the abilities seen as essential to specific task performance. One of the practical applications of this type of taxonomy is in the selection and training of personnel. In their book, *Taxonomies of Human Performance,* Fleischmann and Quaintance (2000) state that, "specific tasks are said to require certain ability profiles if performance is to be maximized. Abilities provide a natural basis for describing and classifying tasks in terms of human performance requirements" (p. 312). Ackerman (2000) stated that research has indicated that ability measures are strong predictors of the abilities of individuals and that task performance remains strong even after lengthy training and skill acquisition.

Extensive, prior research has demonstrated that underlying abilities can be measured accurately (Fleishman & Quaintance, 2000; Gibb, et al. 1991). "Abilities are relatively enduring attributes of the individual performing the task" (p. 153). (Fleishman & Quaintance, 2000) Such abilities are indicators and predictors of later skill development. We know that individuals can be taught skills and, with practice that these skills can be enhanced. However, when an individual possesses an underlying ability that allows them to excel at that skill, they will be enabled to perform tasks based on that skill at a higher level. The researcher is assessing if successful ATCSs possess the underlying cognitive ability style of field dependence.

Herman Witkin (1978) is the person who has identified and developed the concept of field dependence. He sees field dependence as an underlying cognitive

ability. This concept initially emerged from his studies of perception of the upright of a figure in a visual/spatial field in correlation to the position of the subject. In his studies of the Room-Adjustment Test (RAT), and the Body-Adjustment Test (BAT), and the Rod-and-Frame Test (RFT), Witkin (1978), observed significant individual differences in "… the extent to which location of the perceived upright is determined with reference to the axes of the prevailing visual field" (p.17). Witkin and his colleagues also observed that an individual tends to be very consistent in their perceptual performance on the RAT, BAT and the RFT. (Witkin, Dyk, Faterson, Goodenough, and Karp 1962)

Witkin et al. (1962) state that, "a "job analysis" of many classical perceptual phenomena suggests that they may involve the ability to break up a field or overcome an embedding context, in the same way as do their test of perceptual field dependence. It is clear here that the context of Witkin's work is that of the classical figure/ground distinction of the Gestalt Psychologists; Wertheimer, Koffka and Lewin. Thus, Witkin's use of the terms "field" or "embedding context" are to be seen as analogous to the term ground, in the figure/ground terminology of the Gestaltists. As a result of Witkin's research, two classification variables have emerged: one is field dependence which can best be described as an individual relying heavily on external cues in their environment to make decisions. The other classification variable is field independence where an individual relies primarily on internal cues in a self consistent way. According to Witkin (1978), field dependence/independence cognitive abilities are process variables that describe ways of orienting and functioning. These abilities are pervasive dimensions of individual functioning that

account for self-consistency in behavior. They are also stable, bipolar and value-neutral. Further, the existence of any gender differences were not postulates of Witkin's theory of field dependence/independence.

Over the course of his lifetime, Witkin published several books detailing the significant differences in field dependent and field independent individuals (Witkin et al. 1962; see also Witkin, 1978; Witkin and Goodenough, 1981). The following are representative descriptions, according to Witkin of the abilities of each cognitive style: field independent people are thought to be more able than field dependent people in isolating an essential element from the context in which it is presented. They demonstrate strong cognitive restructuring skills, an ability to segregate and manipulate abstract perceptions, and a propensity to function autonomously. (Witkin, 1978). They have a very strong sense of self. They rely primarily on their internal cues and are more constant in their situational behaviors. They also function with a great deal of autonomy in their human relations skills. But, most importantly, according to Witkin (1978) "The internal referents available to field independent people provide them with a fund of mediating mechanisms for use in restructuring a field on their own, when required to do so by a task at hand" (p. 22).

The cognitive restructuring ability of field independent individuals has been demonstrated in tasks of disembedding, spatial reasoning, selective attention, and perspectivism. Perspectivism according to Witkin (1978) is the ability of a field independent individual to realize that another individual may have a different perspective of a fixed stimulus than the perspective that they have. Recognizing this, the field independent individual has the added ability to adopt the other's perspective.

In their extensive literature review, Witkin and Goodenough (1981), show that field independent individuals are more competent in cognitive restructuring tasks than field dependent individuals

On the other hand, field dependent individuals do not exhibit a very high degree of ego strength. They rely heavily on external cues in their environment to make decisions and form their opinions. These individuals have a tendency to drawn on their environment to reach decisions or conclusions. Research supports the notion that these individuals have a greater ability to get along with others. They have what can best be termed as an interpersonal orientation. They seek both a physical and emotional proximity to other individuals. They are sociable and interested in others and possess an innate longing to help others. They tend to take into account and are more sensitive to the thoughts and ideas of other individuals In general, they have a genuine concern for humanity and they have many friends and acquaintances.

To bring these findings into the ATCS realm: a study conducted by Computer Technology Associates, Inc., (Ammerman, et al. 1987) for the FAA identified what they termed the "key human attributes" that an individual must possess to successfully perform ATCS tasks. The CTA study states that these attributes can be categorized into being either cognitive, sensory or motor attribute domains, and, they "represent ability requirements, particularly for the complex sensory, and cognitive aspects of information-processing tasks". The attributes as defined by the authors reach across all areas of ATC, en route, terminal, and tower. Table 1 identifies the 14 attributes that the authors state are key to the work environment of the ATCS, along with a definition of the attribute and ATCS example. These specific attributes are in

line with the underlying abilities that the researcher has identified that are possessed by field independent individuals.

Table 1

Cognitive/Sensory Attributes Definitions

Attributes	Definitions	ATCS Examples
CODING	Transformation or translation of information for entry into the system; Converting textual information to graphics or symbols.	Entering a PIREP; Composing a flight plan amendment.
DECODING	Transformation or translation of information received.	Recognizing a symbol for a handoff; Reading a Flight Data Entry.
DEDUCTIVE REASONING	Ability to reach a conclusion that follows logically from the known facts or data; Selection from among alternative answers or methods.	Concluding that two aircraft are on intersecting paths.
FILTERING	Selection of inputs on which to focus attention in the presence of distracting stimuli or high workload; Selective attention; Overload accommodation.	Identifying communication transmissions for attention during a period of heavy radio traffic.
IMAGE/ PATTERN RECOGNITION	Perception of spatial patterns and relations among static or dynamic visual inputs. May involve orienting oneself to the position or configuration.	Forming a picture of the traffic situation by reviewing Flight Data Entries on the Flight Data Display.

(table continues)

Attributes	Definitions	ATCS Examples
INDUCTIVE REASONING	Generation of an explanation for a set of specific data or instances, giving structure and meaning to the information; Generalization of working hypotheses from specific events; Discerning basic differences and relationships among symbols, figures, and figure patterns; Generating a new solution to a problem; Ability to make a knowledgeable assumption using incomplete data.	Checking the adequacy of a proposed aircraft maneuver.
LONG-TERM MEMORY	Mental storage of knowledge over a period of time and selective recall of items relevant to a situation.	Remembering aircraft characteristics; Remembering procedural instructions or letters of agreement relevant to an uncommon situation, such as an airshow or large flight formation.
MATHEMATICAL / PROBABILISTIC REASONING	Translation of uncertainty into probability; Assigning a subjective probability regarding the likelihood of an event occurring; Ability to use probabilities to identify optimal courses of action.	Assessing the risk of an aircraft maneuver.
MOVEMENT DETECTION	Recognition of the physical movement of a visual object; Estimation of its direction or speed.	Observing aircraft on the Situation Display responding to a clearance or advisory.

(table continues)

Attributes	Definitions	ATCS Examples
PRIORITIZING	Ordering of events in sequence; Establishing priorities.	Deferring a request for flight plan changes in the presence of more urgent activity.
SHORT-TERM MEMORY	Mental storage and selective recall of relevant information over a brief period of time.	Briefly retaining and entering an aircraft call sign.
SPATIAL SCANNING	Rapid identification or detection of objects or events displayed in a wide or complicated visual field.	Observing the Situation Display for new aircraft; Searching for data in a table.
VERBAL FILTERING	Same as FILTERING, but limited to voice communications.	(No example given)
VISUALIZATION	Observation of spatial patterns and subsequent mental transformations into other spatial patterns.	Determining the effect of a proposed aircraft maneuver on other aircraft; Comparing intended time-position profiles for intersection in position/altitude/time.

Note. From FAA Air Traffic Control Operations Concepts, Volume I: ATC Background and Analysis Methodology (p. 3-33 – 3-34), by H. L. Ammerman, E. S. Becker, G. W. Jones, W. K. Tobey, and M. D. Phillips, 1987, Washington, DC: FAA.

The core of what the ATCS does on a day to day basis is to distinguish (disembed) from the totality of the information available to them the information essential for their task…-that of determining the exact coordinates (direction, projected flight path, etc.) of any given aircraft in their airspace in order to maintain separation from other aircraft in that airspace. Research on the screening and selection of ATCS consistently reveals that ATCSs possess the cognitive characteristics of field independent individuals.

In his article, "Characteristics of the air traffic controller", Dailey (1984) states that the central skill of a controller is their ability to simultaneously process a variety of information from many aircraft to create a dynamic mental picture and to use it to plan and control the aircraft. Manning, Kegg and Collins (1989), state that ATCSs abilities to prioritize and strategize events in a dynamic environment include being able to quickly evaluate incoming information, make decisions, and act upon those decisions. Some of the cognitive restructuring abilities of ATCSs are strong decision making skills, selective attention and multi-tasking (Manning, Broach, 1992). The field independent individual demonstrates a propensity for all of these underlying abilities, and testing for these abilities can aid in the initial screening and selection of ATCS candidates

Since these critical skills are cognitive in nature, Sells and Pickrel (1984) have stated that selection tests should emphasize the assessment of cognitive skills, and that historically, selection research has produced better results with tests that measure both cognitive and motor skill aptitudes and abilities.

Research on the subject of ATCS selection includes foreign countries. In their study, “Review of air traffic controller selection: An international perspective,” Broach and Manning (1997), compile the selection criteria of ATCSs in the United States, Germany, the United Kingdom and Sweden. In the United Kingdom, the UK Civil Aviation Authority performed a job task analysis of ATCSs. The required skills that were identified are, “…the rapid processing of information from multiple channels in order to develop and maintain a real-time representation of events in the airspace. Controllers apply this skill, or sets of skills, in a time-pressured repetitive or cyclic work context in the presence of distractions” (p. 10). These skills are essentially what Witkin refers to as perceptual disembedding, a cognitive ability that is innate to, and best performed by, field independent individuals.

The Swedish Civil Aviation Administration also conducted an ATCS job task analysis and found that in the approach control environment decision making and communications were the most important abilities. In contrast, the tower environment requires decision making, information gathering and processing and self confidence. Again, these are all traits of a field independent individual.

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CHAPTER III

RESEARCH METHOD

Design

The researcher conducted a cross sectional study, a collection of data from selected individuals in a specific time period (Emory, 1985), to determine if samples of current USAF and United States Navy (USN) ATCSs possess field independence to a greater extent than non controller military personnel.

Participants

The sample consisted of volunteer enlisted ATCSs on active duty with the United States military. There were three independent groups. The first group was comprised of 19 USAF ATCSs, while the second group had of 19 USN ATCSs. The control group included 19 non-ATCSs who were also enlisted military personnel. The researcher sampled from both the USAF and USN to support the hypothesis that active duty military ATCSs, as a group, possess the underlying ability, or trait of field independence. The researcher coordinated with officials in charge of the Air Traffic Control Facilities from the USAF and USN participating in the study to provide volunteers. The officials estimated that based on the number of ATCSs at their respective locations, the researcher should have no difficulty obtaining a random sample size of a minimum of 19 ATCSs.

The control group consisted of a random sample of 19 active duty, enlisted non-ATCS members from both services, rather than university students, which is often the norm in this type of research. The rationale here wass that a study conducted by Thompson (1998) revealed that a university sample is more similar to an officer sample rather than an enlisted sample. Since both the USAF and the USN use only enlisted personnel as ATCSs, it seemed clear that a control group of university students could well introduce confounding variables into this study. According to Gay and Airasian (1996) confounding variables could have a detrimental effect on the validity of a study. They further state that, "If these variables are not controlled, it is difficult to interpret the results of a study and the groups to which it can be generalized." (p. 383)

Dependent and Independent Variables

A. Dependent

The primary dependent measure was the individual's performance score on the EFT. This defined the participants level of field dependence/independence.

B. Independent

1. Age - The researcher selected age as an independent variable because of its relationship to field dependence. As shown by prior research, Witkin, Oltman, Raskin and Karp (1971) identified a significant decrease in field independence with increasing age.

2. Gender - It is to be noted that, in general, according to Witkin et al. (1971), men tend to be more field independent than women. With the military's approval, the researcher devised a coding system to separate the scores by gender and to protect the gender anonymity of each participant.
3. Job Classification: Military - Job classification codes were used to separate the ATCS sample from the non-ATCS sample. (Job classification and education level may be used to identify confounding problems with the non-ATCS sample. For example, the researcher expects that a sample of participants from other highly analytical career fields would perform on the EFT at about or near the same level as ATCSs.)
4. ATC Environment and years of experience per environment - The researcher collected information relating to ATCS participants only, such as tower/RAPCON experience, and the numbers of years of ATCS experience to further sub-divide the ATCS sample.

Instruments

A. Embedded Figures Test (EFT)

The researcher administered the EFT published by Consulting Psychologists, Press, to all study participants individually to measure their possession of the underlying trait termed field dependence. The EFT consists of 12 simple figures, each embedded in a corresponding complex figure.

The EFT (Witkin, et al., 1971) is a test that has demonstrated a high split-half and test-retest reliability over a number of years and a great variety of studies; i.e., - if the test is administered to a participant, and then administered again in a reasonable

amount of time, there will be no statistically significant difference in the scores. Again, if the EFT is administered to a participant using only the first six figures of the test, or the last six figures, there will be no statistically significant difference between the scores.

B. Questionnaires

The researcher administered entrance (see Appendix A), and exit questionnaires (see Appendix B) to each participant. The researcher designed the entrance questionnaire to collect descriptive statistics about the participants. These statistics are comprised of the independent variables age, job classification code, and work experience and education level. Participants with ATCS experience were asked for their number of years of experience (tower and RAPCON), the amount of time since they last worked as an ATCS and whether they are currently working as tower controllers or RAPCON controllers.

The purpose of the questionnaires was to make the participants feel more involved and open to the testing process. It was important that the participants felt that their opinions and values were on the level of their skill and were being sought by the researcher, thereby helping them to maximizing their efforts when they actually took the EFT.

Procedure

The researcher individually administered the EFT to three groups of participants. The researcher also administered entrance and exit questionnaires to each participant.

The researcher administered the test on an individual basis to each participant. Using a stopwatch, participants were given three minutes to identify the location of the simple figure ("disembed") in the complex figure. Each test was scored by averaging the participant's solution time of the twelve figures. Once the participants were identified, individual testing sessions were scheduled. Testing of all participants, including the non-ATCS sample was completed in 2 weeks. In order to control the test environment, the researcher requested the use of a conference room or private office from both the USAF and USN for the duration of the test at their respective facilities. The researcher posted a "Testing in Progress, Do Not Disturb" sign to the door of the conference room or private office. The researcher administered the test in accordance with the guidance set forth in the manual that accompanies it.

When the participants entered the testing room, the researcher explained who she was, the purpose of the study, and a brief description of field dependence and the EFT, which will followed the test protocols developed by Consulting Psychologist Press. Before administering the test, the researcher asked each participant to fill out an entrance questionnaire that was designed to collect demographic data from all participants. The researcher explained to each participant that the test consisted of 12 sets of simple and complex figures. The test began with a practice form. While viewing this practice form, the researcher told the participants that all the simple figures used in this test will appear in the complex form in the upright position, and will be of the same size and shape. The participants observed a complex figure for 15 seconds and then a simple figure for 10 seconds. The researcher instructed the

participants that as soon as they visualized the simple figure in the complex figure to verbalize, “I see it”. Then, using a stylus the participants traced the simple figure so that the researcher could determine if they correctly identified the simple figure. The researcher noted the time on the stopwatch when the participant first verbalized to her, “I see it”, but the stopwatch would continue to run until the participant correctly traced the simple figure. If the tracing correctly identified the simple figure the researcher annotated the time that the participant first said “I see it”. If the identification was incorrect, the researcher informed the participant, “no, that’s not correct”, and the test continued. The test continued until the participant either correctly identified the simple figure, or the three minute time limit per figure had lapsed. The researcher informed the participant that they could, at any time, ask to see the simple figure again. The researcher stopped timing the participant and gave them 10 seconds to view the simple figure again. The researcher determined the participant's score by averaging the solution time scores, in seconds, for all 12 figures (see Appendix D). After completing all 12 figures, the participant filled out an exit questionnaire. The researcher conducted the data collection effort from January 16-24, 2001.

Analysis

After administering the EFT and the questionnaires to all participants, the researcher analyzed the data. The null hypothesis in this study was that any differences found between the average scores on the EFT of the three groups of participants, will be due to error variance. For the three independent samples the One-way Analysis of Variance (ANOVA) was the appropriate test of statistical

significance to use in this study (Emory, 1985). To reject the null hypothesis, the analysis had to demonstrate a significant statistical difference between the EFT scores of the ATCS sample and the non-ATCS sample.

Treatment of Questionnaire Data

Given the military's sensitivity and concern for possible uses of personal data concerning their members, the personal data and test scores were safeguarded and available to no one. The researcher was only concerned with the EFT scores, not with who achieved them. Participants were not asked to sign/use their names in any way to take the test. All that was recorded were the test scores. Thus, no one can link a test score to a specific participant.

The demographic data from the questionnaires was de-identified and presented by using either summations or averages of the categories. All of the pertinent data were transposed to a spreadsheet. Frequency tables were developed for each question. The researcher correlated, cross tabulated, and examined the demographic differences amoung the three groups. All questionnaires were destroyed. The data and results are non-attributable and nowhere in the study are the actual military installations where the testing was conducted identified.

CHAPTER IV

RESULTS

The primary purpose of the analyses were to determine if a sample of active duty ATCSs from the USAF and USN were comprised of a greater number of participants possessing the underlying ability or trait of field independence than participants in the non controller military sample. The performance indicator was the score on the EFT. The researcher conducted additional analyses to investigate the relationships between the EFT scores and the independent variables for this study which were, participant age, gender, job classification and where applicable, years of ATC experience.

Descriptive Statistics of Participant Groups

The researcher designed questions 1 through 5 on the entrance questionnaire to collect descriptive statistics from all participants. Questions 11 through 14 collected additional information. The researcher used these descriptive statistics to stratify and describe the three samples of participants. The three samples were composed of USAF ATCSs (Group 1), USN ATCSs (Group 2), and the control group which consisted of both USAF and USN non controller personnel (Group 3).

The sample of USAF ATCSs, consisted of 19 participants of varying skill levels and ATC field assignments. There were 6 Apprentice ATCSs (1C131), 10

Journeyman ATCSs (1C151), and 3 Craftsman ATCSs (1C171). Of that group, 10 were Tower ATCSs, 8 were Rapcon ATCSs, and 1 who was not currently performing the duties of an ATCS. There were 9 male participants and 10 females. The mean age of the participants was 25.6 years, with a median age of 26 years. There was a range in ages, from 19 to 39. The mean for active duty years was 4.91 years, and the median was three years, ranging from 1 to 18.5 years. Six of the participants possessed a high school education. Eight participants had some college experience. Three had an Associates Degree, and two had a Bachelors Degree.

The sample of USN ATCSs, consisted of 19 participants of varying skill levels and ATC field assignments. There were 8 ATCSs, 4 ATCS Supervisors, and 7 ATCS Chiefs. Of that group, 5 were Tower ATCSs, 10 were both Ground Control Approach (Rapcon), and Tower ATCSs, and 4 were not currently performing the duties of an ATCS. There were 13 male participants and 6 females. The mean age of the participants was 32 years, with a median age of 33 years. There was a range in ages, from 22 to 47. The mean for active duty years was 12 years, and the median was 12.5 years, ranging from 2.75 to 24 years. Nine of the participants possessed a high school education. Seven participants had some college experience, 2 had an Associates Degree, and 1 had a Bachelors Degree.

The control group consisted of a sample of 19 non-ATCSs participants of varying occupations and skill levels from both the USAF and the USN. This group was composed of participants from 16 different career fields. See Table 2.

Table 2

Control Group Job Specialty Distribution

Job Specialty Title	Number
Satellite and Wideband Communications Equipment	2
Computer Maintenance	1
Communication Computer Operator	1
Communications Computer Systems Control Technician	1
Personnel Clerk	1
Maintenance Data Systems Analyst	2
Supply Apprentice	1
Contracting Specialist	1
Training Manager	1
Fuel Resource Controller	1
Aircraft Handler	2
T-Line Landing Position Officer	1
Aviation Structural Mechanic	1
Jet Mechanic	1
Weapons Officer	1
Aviation Machinist Mate	1

There were 13 male participants and 6 females. The mean age of the participants was 29.5 years, with a median age of 28 years. There was a range in ages, from 19 to 41. The mean for active duty years was 8.3 years, and the median was 7 years, ranging from 6 to 22 years. Eight of the participants possessed a high school education. Eight participants had some college experience, 2 had an Associates Degree, and 1 had a Bachelors Degree.

Analysis of EFT Scores

The mean scores, and their standard deviations, on the EFT for each participant group are presented in Table 3.

Table 3

EFT Mean Scores by Groups

EFT Scores	N	Mean EFT Raw Score Seconds	Std. Deviation	Mean Std. T-Score	Std. Deviation
USAF ATCS	19	30.56	12.76	46.25	8.36
USN ATCS	19	35.58	12.57	49.54	8.24
Control Group	19	42.72	18.04	54.21	11.82

Results of the EFT for Field Independence/Dependence

According to Witkin, et. al (1962), in order to determine if an individual is field dependent/independent the raw EFT score in a study must be converted into standard scores using means and standard deviations by gender. Once converted into standard scores, scores below the 50 percentile, (the fastest scores) indicated field independence. Scores above the 50 percentile (the slower scores) indicated field dependence. The researcher converted the raw scores into standard z scores by using the formula (individual EFT score – EFT mean score by gender)/standard deviation by gender. The EFT mean score for male participants was 36.86 seconds, with a standard deviation of 15.57. The EFT mean score for the female participants was 35.38, with a standard deviation of 15.09. The researcher then converted the z scores into t scores by multiplying each z score by 10 and adding 50. T scores, assuming a semetric distribution, have a standardized mean of 50 which falls on the 50th

percentile. A t score of 50 could be used as the cut point for interpreting Witkins guidance in using percentiles. See Table 4.

Table 4

Field Independence/Dependence by Participant Groups based on Standard Scores

	Field Dependent		Field Independent	
Group	Number	Percentage	Number	Percentage
USAF ATC	5	26%	14	74%
USN ATC	6	32%	13	68%
Control Group	10	53%	9	47%

The researcher conducted a one way ANOVA on the EFT scores of the three participant groups. The analysis revealed that a significant statistical difference ($p<.05$), exists between the means of the EFT scores for the three groups. See Table 5. The ANOVA only provides information that a difference exists, it does not specify where that difference lies.

Table 5

One Way ANOVA

EFT Score	Sum of Squares	df	Mean Square	F	Sig.	Fcrit
Between Groups	1418.50	2	709.25	3.29	*	3.17
Within Groups	11639.89	54	215.55			
Total	13058.40	56				

Note. *$p<.05$.

The correlation ratio is the proportion of variance accountable by the main effect. The main effect of this study was possession of ATC experience. The researcher obtained a correlation ratio of .108 by dividing the between group sum of squares (1418.50) by the total sum of squares (13058.40). "While the F ratio was not that large, a correlation ratio of .108 suggests an effect equal to or greater than many published results which generally do not bother to compute it" (E. S. Stein, personal communication, March 15, 2001).

The significant F allowed the rejection of the null hypothesis that the groups were the same. To determine where the differences actually existed between the participant groups, the researcher conducted a Scheffe post-hoc test. This test revealed that there was only one significant paired comparison, that between the USAF ATCSs and the Control Group. See Table 6.

Table 6

Scheffe Post Hoc Test

Group	USAF ATCS	USN ATCS	Control Group
USAF ATCS	N/S	N/S	*
USN ATCS			N/S
Control Group			

Note.*p<.05. df 2, 54

The researcher also conducted a Pearson Correlation Analysis using the EFT scores, age, AD years, education, group and gender to identify any relationships between the factors. This test revealed a correlation between age and active duty

years; gender and age; and EFT score and group. The results are presented in Table 7 which cites only those correlations significant ($p < .05$) from zero.

Table 7

Pearson Correlation

	AD Years	Age	Education	Group	EFT Score	Gender
AD Years	--	.910*	--	--	--	--
Age	--	--	--	--	--	.323*
Education	--	--	--	--	--	--
Group	--	--	--	--	.328*	--
EFT Score	--	--	--	--	--	--
Gender	--	--	--	--	--	--

Note.*$p<.05$.

Treatment of entrance and exit questions.

The researcher summarized the responses to each question by group in individual frequency tables. The entrance and exit questions that were related by having similar content, are presented sequentially.

Entrance questions 6 was, "I have extensive experience in ATC Ops". This statement is related to the number of years of ATC experience. Nine of the USAF ATCSs and thirteen of the USN ATCSs expressed agreement with this statement. This could be attributed to the USN ATCS group having more years of ATC experience. Five of the non-controller group agreed with this statement. The majority of the non-controller group may have expressed strong disagreement with

this statement because their career fields were not involved in air traffic control operations. See Table 8.

Table 8

Frequency Table for Entrance Question 6

"I have extensive experience in ATC Ops"

Group	Strongly Disagree 1	2	3	4	5	Strongly Agree 6
USAF ATCS	0	2	8	3	4	2
USN ATCS	2	0	4	3	3	7
Non-Controllers	12	1	1	0	3	2

Entrance question 7 was, "In ATC Ops I am (more or less skilled than the other participants)". The USN ATCS group rated themselves as being more skilled than the USAF ATCS group and the non-controller group. This again, could be attributed to the USN ATCS group having more years of ATC experience. The two participants from the non-controller group that rated themselves toward the very highly skilled end of the continuum were USN personnel in ATC Ops positions. In the USN ATC Ops positions include specialties other than ATCSs. See Table 9.

Table 9

Frequency Table for Entrance Question 7

"In ATC Ops I am ….."

Group	Not Skilled 1	2	3	4	5	Very Highly Skilled 6
USAF ATCS	0	0	5	6	7	1
USN ATCS	0	0	2	2	8	7
Non-Controllers	14	3	0	1	1	0

Exit question 4 "My experience in ATC Ops is (such that I am not at all to very highly skilled in ATC Ops)". was related to entrance question 7., These results are presented in Table 10. The self reported skill level expressed by the participants were basically the same on both entrance question 7 and exit question 4; thus there was no significant difference with the participants post treatment opinion. See Table 10.

Table 10

Frequency Table for Exit Question 4

"My experience in ATC Ops is ….."

Group	Not Skilled 1	2	3	4	5	Very Highly Skilled 6
USAF ATCS	0	0	5	8	5	1
USN ATCS	0	0	2	4	5	8
Non-Controllers	14	1	2	0	2	0

Entrance question 8 was, "I will perform on the test relative to the others". The ATCS from both the USAF and the USN self reported that they would perform higher on the EFT than other participants. See Table 11.

Table 11

Frequency Table for Entrance Question 8

"I will perform on the test relative to the others …."

Group	Lower 1	2	3	4	5	Higher 6
USAF ATCS	0	0	3	10	5	1
USN ATCS	0	0	3	4	12	0
Non-Controllers	2	2	8	4	2	1

Exit question 1, "I believe my performance on the test relative to the others was…", is related to entrance question 8. In general after taking the EFT all groups self reported their performance at a lower level than before they took the EFT. See Table 12.

Frequency Table for Exit Question 1

"I believe my performance on the test relative to the others was ….."

Group	Lower 1	2	3	4	5	Higher 6
USAF ATCS	0	1	5	11	1	1
USN ATCS	1	2	3	11	2	0
Non-Controllers	0	3	10	6	0	0

Entrance question 9 was, “I will know most of the participants very well”. In general, both the USAF and USN ATCSs reported knowing the other participants better than the non-controller group. This was an expected result because the non-controller group was composed of participants from various career fields. See Tables 13.

Table 13

Frequency Table for Entrance Question 9

“I will know most of the participants very well”

Group	Strongly Disagree 1	2	3	4	5	Strongly Agree 6
USAF ATCS	0	1	1	6	7	4
USN ATCS	0	0	1	5	7	6
Non-Controllers	6	5	3	1	3	1

Exit question 2 was, “I did know most of the participants very well”. This question was related to entrance question 9. The researcher found no significant difference in the opinions expressed by the participants. See Table 14.

Table 14

Frequency Table for Exit Question 2

"I did know most of the participants very well"

Group	Strongly Disagree 1	2	3	4	5	Strongly Agree 6
USAF ATCS	0	1	4	5	3	6
USN ATCS	0	0	2	4	9	4
Non-Controllers	3	3	7	1	4	1

Entrance question 15, "I am anticipating that the test I will take relates to ATC skills", was only asked of ATCS participants. The only knowledge the participants had of the EFT before taking the test was what the researcher divulged to them in accordance with the guidelines in the EFT manual that accompanies the test. The majority of the ATCSs, before taking the EFT anticipated that this test was related to ATC skills. See Table 15.

Table 15

Frequency Table for Entrance Question 15

"I am anticipating that the test I will take relates to ATC skills …"

Group	Strongly Disagree 1	2	3	4	5	Strongly Agree 6
USAF ATCS	1	0	2	7	3	6
USN ATCS	0	1	2	8	6	2

Exit question 3, “The test I took relates to ATC skills”, is related to entrance question 15. The non-controller group scores were eliminated from this question, so that the researcher could compare the ATC results with entrance question 15 which was only asked of the ATCS participants. There was a significant diffrence in the ATCSs self reported opinion concerning the EFT’s relation to ATC skills. The number of ATC participants that strongly disagreed with the EFT’s relation to ATC skills nearly doubled after the participants took the test. This suggests that the participants anticipated that the EFT would relate to ATC skills before actually taking the test, and upon completion of the test, the participants reevaluated their opinions. See Table 16.

Table 16

Frequency Table for Exit Question 3

“The test I took relates to ATC skills …”

Group	Strongly Disagree 1	2	3	4	5	Strongly Agree 6
USAF ATCS	2	0	5	8	4	0
USN ATCS	1	4	3	7	4	0

CHAPTER V

DISCUSSION

This research project examined if a sample group of active duty military ATCSs, as a group, were more field independent than a comparable group of non-controller military personnel. To provide an initial measure of generalizability for the hypothesis, the researcher selected two samples of controllers from two different armed services. The researcher conducted an analysis comparing the EFT scores of the two ATC groups with a control group that was composed of non-ATCSs. The analyses revealed that the majority of the USAF ATCSs (74%) and USN ATCSs (68%) were field independent. Only 43% of the control group participants were field independent.

The researcher established a null hypothesis that there was no significant statistical difference between the EFT scores of the two ATC groups. The absence of a significant statistical difference would suggest that the EFT did not discriminate ATC participants from the USAF and USN respectively. The mean score for the USAF ATCS sample was 30.56 (12.8) seconds per figure, and the mean score for the USN ATCS sample was 35.58 (12.6) seconds per figure. The variances within the two groups were essentially the same. The data clearly suggests that controllers do

not differ on EFT performance across services. The only sampling criteria the researcher could control *a priori* in selecting two samples of ATCs, was their branch of the military and the air traffic density of their respective facilities. However, the research revealed there were some demographic differences even with homogeneity in field independence.

The USAF ATCS group was the youngest with a mean age of 25.6 years. The mean age of the USN ATCS group was 32 years. The gender composition of the USAF sample was split between 9 males and 10 females. While the gender composition of the USN ATCSs was 13 males and 6 females. The USAF sample was slightly more educated, possessing a higher number of advanced degrees. The experience of the two ATC samples also differed. The USAF ATCSs were either tower (10) or RAPCON (8) controllers, and one participant was not currently performing ATCS duties. Ten of the USN ATCSs were dual rated, possessing experience in the tower and ground control approach (the USN's term for RAPCON). Five of the participants were solely tower ATCS, and 4 were currently not performing ATCS duties

The researcher anticipated finding significant differences between the two ATCS groups and the control group. However, the data analysis revealed a statistically significant difference only between the EFT mean score per figure of the USAF ATCSs (who possessed the fastest, i.e. lowest mean score per item of any group) and the mean scores of the control group. The mean score per figure for the control group, was the highest, i.e. slowest, at 42.72 seconds per figure, with a standard deviation of 18.04. It is possible that the absence of a significant difference

between the USN ATCSs and the control group could be attributed to non-controlled variables in the samples.

These two groups were similar in their average age, gender composition and education. The average age of the control group fell in between the two groups of ATCSs, at 29.5 years. The gender composition of the USN ATCSs and the control group was the same, with 13 males and 6 females. The USN sample and the control group also had a higher number of participants with only high school degrees.

The Pearson Correlations across the independent variables revealed that significant correlations (at the $p<.05$ level), exist between age and active duty years; gender and age; and the EFT score and group. The correlation between the EFT score and group is an expected one because of the significant ANOVA, which is another way to look at variance. While correlation by no means infers causation, it is possible that some varying combination among factors may have had some effect on the results.

While the correlation between age and active duty is a statistically significant, it is an expected finding. The longer individuals are on active duty, the older they are. The researcher believes that the relationship of gender and age is probably due to sampling. The correlation between EFT score and group may be indicative of the occupation of the study participants. Since occupation was the principal independent variable of this study, and the ANOVA revealed significant statistical differences between one of the ATCS groups and the control group, it was no surprise that a correlation exists between the EFT score and group.

CHAPTER VI

CONCLUSIONS

Based on the results of this study, it seems apparent that on average the samples from the USN and the USAF ATCSs possess the underlying ability or trait of field independence. These two samples were from two different branches of the military, two different levels of facilities and were composed of differing age groups. However, as a group they were homogenous. The findings suggest that field independence is an ability or underlying trait of ATCSs, and this warrants further research. This will involve several aspects, the first being longitudinal studies that determine if possession of field independence (as opposed to being field dependent) has a positive impact on both training success and later job performance.

The main avenues of future research that this study points to are three-fold. The first area for future research is whether or not field independence/field dependence is a trait that effective US Army ATCS', and more importantly, FAA ATCS' possess. If this is true, then, field independence can be considered as an essential trait of an ATCS. Complementary to such future R & D would be a

longitudinal study to track ATCS' with field independence versus ATCS' who are field dependent to see what their performance differences are over time.

Secondly, research is needed on the effects of using the EFT as a screening or selection tool for ATCS candidates. There are existing tests for such selection and screening. The UK, Australia, New Zealand, Canada and the FAA have and use such tests. It should be noted however, that none of these tests measure field dependence/independence directly. Research on whether or not the addition of the EFT to such existing test batteries improves their predictive validity seems a natural step. However, much larger samples would be necessary for research, and in the United States there are exiting federal regulations that govern pre-employment and employment testing. These two factors would govern such further research.

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CHAPTER VII

RECOMMENDATIONS

Computerization of the EFT, both in administration and scoring, is central to any future research. Administering and scoring this test manually is a time intensive task, which requires the undivided attention of the personnel administering the test. Considering the current efforts toward government downsizing and the armed services' budgets, computerizing this test would reduce the personnel burden necessary to conduct the test. In order to successfully use this test nationwide to screen candidates, a computerized EFT is a necessity in both a practical and an economical sense.

The first recommendation based on the results of this research, is that comparisons between existing ATCS candidates' screening and selection tests be done to ascertain if the EFT is being used by any other organization, specifically the FAA and foreign countries.

The second recommendation is that the US Military (and, if possible, the FAA) to conduct studies to determine if and how the EFT can be used as a screening tool for entrance into military ATCS training. The EFT was successful in characterizing the USAF and USN ATC participants as field independent, although the USN personnel were not significantly more field independent that the control

group. However, before it could be used as a predictor of ATC performance, additional data is needed. The EFT, combined with the ASVAB into a battery may prove to be a better predictor than the ASVAB alone. In order to begin this effort, the first step is to conduct a cross sectional study then to conduct a longitudinal study that will determine if possession of field independence (as opposed to being field dependent) has a positive impact on both training success and later job performance.

The longitudinal studies should start by administering the EFT to all students prior to entering their respective military ATC technical schools. The study should then track all students, broken into those who are field independent versus those who are field dependent throughout their training from entry to technical school, through full facility certification at their first ATC facility. The study must collect a complete set of data including ASVAB scores, EFT scores, and all school and on-the-job training measurements of performance.

Finally, researchers should determine if there are any changes in predictive validity made by the addition of the EFT to any/all existing, computerized ATCS selection batteries. As one example, the New Zealand ATCS selection battery could be a starting point.

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APPENDIX A

ENTRANCE QUESTIONNAIRE

ENTRANCE QUESTIONNAIRE

1. What is your age? _____

2. What is the highest level of education that you have completed?

☒ Graduated high school
☒ Attend(ed) college (approximate credit hours completed) _____
☒ Associate Degree
☒ Bachelor Degree

3. What is your primary AFSC -- both code number including skill level and job series title?

_____

4. Do you have a secondary AFSC?
If so, please provide AFSC and job series title.

_____

5. How many years have you been in the military?

_____

6. I have extensive experience in ATC Ops.
(circle the number that best reflects your agreement)

Strongly Disagree 1 2 3 4 5 6 Strongly Agree

7. In ATC Ops I am:

Not skilled at all 1 2 3 4 5 6 Very highly skilled

8. I will perform on the test relative to the others:

Much Lower 1 2 3 4 5 6 Much Higher

9. I will know most of the participants very well.

Strongly Disagree 1 2 3 4 5 6 Strongly Agree

10. Are you an Air Traffic Controller?
If yes, continue. If no, you may stop now.

_____

11. How many years of experience do you have as an ATCS in:

Tower _____ Rapcon _____

12. Are you actively "working the boards"? _____

_____ Tower _____ Rapcon

13. If not, how long has it been since you last did?

_____

14. How many hours have you worked the boards in the past two weeks? _____

_____ Tower _____ Rapcon

15. I am anticipating that the test I will take relates to ATC skills.

Strongly Disagree Strongly Agree

1 2 3 4 5 6

APPENDIX B

EXIT QUESTIONNAIRE

EXIT QUESTIONNAIRE

1. I believe my performance on the test relative to others was:

Lower						Higher
	1	2	3	4	5	6

2. I did know most of the participants very well.

Strongly Disagree						Strongly Agree
	1	2	3	4	5	6

3. The test that I took relates to ATC skills:

Strongly Disagree						Strongly Agree
	1	2	3	4	5	6

4. My experience in ATC Ops is:

Not skilled at all						Very highly skilled
	1	2	3	4	5	6

APPENDIX C

EFT SCORE SHEET

Practice Item: Solution Time_____

Item #	Comments	Time Data	Solution Time
1-A			
2-B			
3-C			
4-D			
5-E			
6-A			
7-F			
8-E			
9-C			
10-G			
11-A			
12-H			

Total Time in Seconds _____